APPENDIX B

GEOPHYSICAL SURVEY INVESTIGATION REPORT

FINAL REPORT

Geophysical Investigation at Parcels 3 and 10 of the Former Georgia Pacific Sawmill site in Fort Bragg, California

Submitted to:

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1. INTRODUCTION

3Dgeophysics.com (3Dg) performed a geophysical investigation at the Former Georgia Pacific Sawmill site located in Ft. Bragg, CA (the “site”). The work was conducted within Parcel 3 (Industrial parcel) and Parcel 10 (South Coastal Zone parcel) of the site. The geophysical investigation consisted of an EM61 metal detector survey and an EM31 ground conductivity survey in each of the study areas. This work was completed under the authorization of Mr. Mohammad R. Bazargani from TRC Companies, Inc. (TRC). The geophysical data were collected on August 17 – 18, 2004. The objective of the investigation was to map potential buried metal objects and variations in the near surface sediments at the site. The results of this study will be used to help determine the environmental management alternatives at the site.

The approximate location of the study areas is shown on an aerial photograph of the site in **Figure 1**. The purpose of the work was to create a detailed image of the subsurface, and to provide a high resolution map of buried metal objects at the site.

2. METHODOLOGY

The geophysical investigation consisted of two geophysical techniques including electromagnetic (EM) metal detection and ground conductivity mapping. A Differential Global Positioning System (DGPS) was integrated with the geophysical equipment and used for position control during the EM surveys. **Table 1** summarizes the methodology and instrumentation used for the investigation.

A non-magnetic and non-conductive instrument trailer and a 4x4 all-terrain vehicle (ATV) were used to collect the geophysical data. An OmniStar enabled DGPS with sub-meter accuracy (Trimble Ag 114) was connected directly to the EM instruments to provide position control for each of the EM surveys. Accuracy and reliability of the DGPS system was subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. DGPS surveying conditions at the site were excellent. As many as 10 and no fewer than 7 satellites were visible to the GPS receiver during the survey (only 5 satellites are required for DGPS measurements). **Figure 2** shows photographs of the data acquisition system used for the geophysical surveys.

Prior to the start of data collection the boundaries of the study areas were identified in the field by Mohammad Bazargani (TRC) and Dr. Craig Hunt (CA Regional Water Quality Control Board). The perimeters of the study areas were then walked and precisely mapped using the DGPS and a ruggedized Pocket-PC running GIS software (HGIS, StarPal, Inc.). After the survey area boundaries were mapped the GIS software was used to generate 10 x 10 ft survey grids over the study areas within the defined perimeters. Data collection required driving the ATV and instrument trailer across the site according generated survey grids. The Pocket-PC running the HGIS software was mounted to the utility vehicle and the survey grid overlays were used to navigate across the site. The data acquisition system was driven along the 10 ft survey grid lines in each of the two survey areas to completely sample the areas of interest. Each survey area was driven with the data acquisition system twice during the investigation; once with each of the EM instruments. The EM61 data were collected first at both study areas, the equipment on the instrument trailer was changed, and then the EM31 data were collected.

2.1 EM61 METAL DETECTION SURVEY

EM61 is a non-invasive EM imaging technique used to identify metallic objects in the near subsurface. The EM61 metal detection system measures the localized and momentary changes in magnetic fields caused by eddy currents induced around buried metal objects. The eddy currents are caused by the interaction of the primary EM field created by a transmitter coil on the EM61 system and buried conductive bodies like utilities, steel tanks, buried debris or other metal objects. **Figure 3** shows an illustration of the theory of operation of the EM61 system.

The EM61 system measures the induced eddy currents which flow around buried conductive objects such as utilities, pipes, and buried debris. A transmitter coil is used to produce the primary field and generate the induced eddy currents. After the primary field is shut off the eddy currents are monitored by the receiver coil for a period of 10 to 20 milliseconds. Within sediment and rock the eddy currents normally dissipate within a few milliseconds. The eddy currents dissipate much more slowly when buried metallic objects are present. This measurement process occurs as fast as 16 times per second.

The cart-mounted EM61, which operated continuously, was systematically pulled on the instrument trailer by the ATV across the site to cover the areas of concern. EM data were collected with sufficient spatial sampling to detect buried metal objects of potential environmental concern. **Table 2** summarizes the recording parameters that were used for the investigation.

After the field work was completed the EM61 data were processed using the DAT61MK2 software package (Geonics, Ltd.) and a PC workstation. The geo-referenced data were then interpolated into a regular grid and plotted using the Surfer surface mapping software program (Golden Software, Denver, CO).

2.2 EM31 GROUND CONDUCTIVITY SURVEY

An electromagnetic (EM) conductivity survey was used to map the electrical properties of the near subsurface sediments at the site. Clayey materials, saturated sediments and weathered bedrock are generally electrically conductive, while sandy, dry materials and unaltered bedrock are generally more resistive. Areas on the site that contain reworked sediments, which may be indicative of burial pits or fill areas, would be expected to produce ground conductivity anomalies.

TABLE 1: METHODOLOGY & DATA ACQUISITION EQUIPMENT

Method	Instrument	Specifications
EM Metal Detection	Geonics EM61	High Power Mark2, Dual Coil
EM Ground Conductivity mapping	Geonics EM31	Mark2, Digital Output
Surveying	Trimble GPS	Model Ag-114 Differential (OmniStar enabled)

TABLE 2: DATA ACQUISTION PARAMETERS

Parameter	Value
EM61 Power Mode	Low
Coil Type	1.0 x 0.5 meter
EM61 Operation Mode	Differential: 4 time windows
Sampling Interval	10 samples/sec
No. of Samples	Parcel 3: 29,727 Parcel 10: 49,366
Approximate Survey Size	Parcel 3: 201,500 sq feet (4.6 acres) Parcel 10: 353,000 sq feet (8.1 acres)

TABLE 3: GROUND CONDUCTIVITY DATA COLLECTION PARAMETERS

Parameter	Value
Dipole Orientation	Vertical
Sampling Interval	10 samples/sec
No. of Samples	Parcel 3: 15,791 Parcel 10: 31,758
Approximate Survey Size	Parcel 3: 189,400 sq feet (4.3 acres) Parcel 10: 292,300 sq feet (6.7 acres)

The EM31 system measures the change in localized magnetic fields caused by the conductivity of the near surface sediments. The current flow in the sediments is induced by a primary EM field which is generated by a transmitter coil on the EM31 system. A receiver coil on the EM31 then measures the resultant field at a fixed offset from the transmitter. The amplitude and phase shift of the measured EM field is directly related to the bulk conductivity of the sediments below the EM31 instrument. **Figure 4** shows an illustration of the theory of operation of the EM31 ground conductivity meter.

The cart-mounted EM31, which operated continuously, was systematically pulled on the instrument trailer by the ATV across the site to cover the areas of concern. EM data were collected with a 10 Hz sampling frequency (10 samples/second). **Table 3** summarizes the recording parameters that were used for the investigation.

After the field work was completed the EM31 data were processed using the DAT31W software package (Geonics, Ltd.) and a PC workstation. The geo-referenced data were then interpolated into a regular grid and plotted using the Surfer surface mapping software program.

TABLE 4: SITE SURFACE FEATURES

Parcel	Label	Note
3	1	boring/test pit location
	2	boring/test pit location
	3	boring/test pit location
	4	concrete slab / debris
	5	concrete slab / debris
	6	concrete slab / debris
	7	boring/test pit location
	8	hydrant
	9	barrier pole
	10	hydrant
	11	power pole
	12	hydrant
	13	power pole
10	1	rock outcrop
	2	center of 8/17/04 excavation
	3	rock pile

3. RESULTS

3.1 EM61 METAL DETECTION SURVEY

Figures 5 – 6 show the data coverage maps that display the actual sampling locations where EM61 data were collected in Parcels 3 and 10 during the investigation. The data gap that occurred in the Parcel 3 survey area was the result of an abrupt topography change (small sediment berm) that was inaccessible with the ATV-towed system. All of the EM data were reviewed for quality control both in the field and then in the office.

Figures 7 – 8 show the annotated EM61 anomaly maps for the survey areas. These plots are contour maps of the EM response (measured in millivolts) at various DGPS positions after the data were interpolated into an evenly-spaced grid. Large EM responses (anomalies) occur over very shallow or large buried metallic objects, and are colored green, yellow, and red. A careful review of the EM data suggests that the quality is excellent. The locations of some significant surface features are identified on the maps in Figures 7 – 8. **Table 4** lists the surface features shown on the maps. Site features were located with the DGPS and a handheld field GIS system after the EM data collection was completed.

Significant occurrences of metal are apparent in the western portion of Parcel 3, west of the sediment berm, and in the center of the Parcel 10 study area. Note the EM response from the railroad tracks and the water pipe connecting the fire hydrants in Parcel 3 (Figure 7).

The site plan shown in Figures 5 – 8 was provided by TRC. The geophysical anomaly maps were created from DGPS data, but 3Dg cannot verify the accuracy of the site plan. Therefore, 3Dg makes no claims regarding the relationship of the features on the site plan to the geophysical anomalies. However, the geophysical anomalies can be identified in the field by using GPS coordinates.

3.2 EM31 GROUND CONDUCTIVITY SURVEY

Figures 9 – 10 show the data coverage maps that display the actual sampling locations where EM31 data were collected in Parcels 3 and 10 during the investigation. Note the data gap as the result of the sediment berm in Parcel 3.

Figures 11 - 12 show the annotated EM31 ground conductivity maps for the survey areas. Important surface features (Table 4) are labeled on the figures. The data plots are color-coded contour maps of the ground conductivity across the survey area. Ground conductivity is measured in millisiemens/meter (mS/m). The color scale for each of the ground conductivity maps has been optimized to isolate conductivity anomalies. In general, high conductivity (low resistance) areas are shaded red, orange, and yellow, while low conductivity (high resistance) areas are shaded green, blue, and purple. The EM31 system measures bulk conductivity of the earth from the ground surface to the maximum depth of penetration. Ground conductivity measurements are primarily influenced by soil/sediment type, proximity of bedrock to the ground surface, and moisture content.

No significant conductivities anomalies appear in the Parcel 3 map (Figure 11), with the exception of the response from the railroad tracks and the water pipe connecting the fire hydrants. High conductivity anomalies are apparent in the central and southeastern portions of the Parcel 10 study area, and are outlined in black in Figure 12.

The site plan shown in Figures 9 – 12 was provided by TRC. The geophysical anomaly maps were created from DGPS data, but 3Dg cannot verify the accuracy of the site plan. Therefore, 3Dg makes no claims regarding the relationship of the features on the site plan to the geophysical anomalies. However, the geophysical anomalies can be identified in the field by using GPS coordinates.

4. CONCLUSIONS

The EM techniques used for the work successfully met the objectives of the project which were to map buried metal objects and variations in the near surface sediments at the site. The following conclusions, which represent one interpretation of the geophysical data, resulted from the work:

- **Parcel 3**: Many EM61 anomalies are present in the western portion of the study area, adjacent to the sediment berm that bisects the site. The relative size and intensity of the anomalies does not suggest that extremely large metal objects (such as tanks or drums) are buried at the site. The conductivity of the near surface sediments is uniform across the site, which indicates that no reworked soil or fill areas exist within the study area. Considering the facts that a scrap pile was formerly located within the study area, the EM31 data indicate no significant ground conductivity changes near the EM61 metal detection anomalies, and that many occurrences of small pieces of scrap metal were found in the study area during the investigation suggests that the majority EM anomalies mapped in the survey area probably represent smaller metal objects such as debris that are located on the surface of the site or buried at a shallow depth. The EM61 map clearly delineates the positions of the buried metal and the lateral extent of the buried metal.
- **Parcel 10**: Many EM61 anomalies are present in the central portion of the study area. The relative size and intensity of the anomalies suggests that the anomalies represent buried metal objects. The area in which the metal detection anomalies are located correlates with an area of higher ground conductivity as mapped by the EM31 survey. The EM31 data suggest that different sediment types, fill, or reworked soil are located in the areas exhibiting higher ground conductivity. No significant surface metal or debris was noted within the survey area during the investigation. The EM61 map clearly delineates the positions of the buried metal and the lateral extent of the buried metal.

FIGURES

N

APPROXIMATE SCALE (FEET)
0 500 1,000

SOURCE: WAC Corp. Aerial Photograph, April 15, 1999.

PARCEL DESIGNATIONS

1. North Coastal Zone
2. Resaw Plant/PMF Lease
3. Industrial
4. Power House
5. Sawmill No. 1
6. Planer
7. Sawmill No. 2
8. Log Storage
9. Nursery
10. South Coastal Zone

ADDITIONAL SITE FEATURES

- (A) Water Treatment Plant
- (B) Sailors' Cemetery
- (C) Johnson's Point
- (D) Campbell Lease Buildings (Main Office)
- (E) Noyo Indian Community

PARCEL DESIGNATIONS

Georgia-Pacific
California Wood Products
Manufacturing Division
90 West Redwood Avenue
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Title: Geophysical Study Areas and Site Photograph

Reference: aerial photograph provided by TRC

Figure No. 1

(A) 4X4 ATV and Instrument Trailer with EM61 and GPS equipment

(B) 4X4 ATV with EM61 electronics

(C) ATV with data logger & navigation computer

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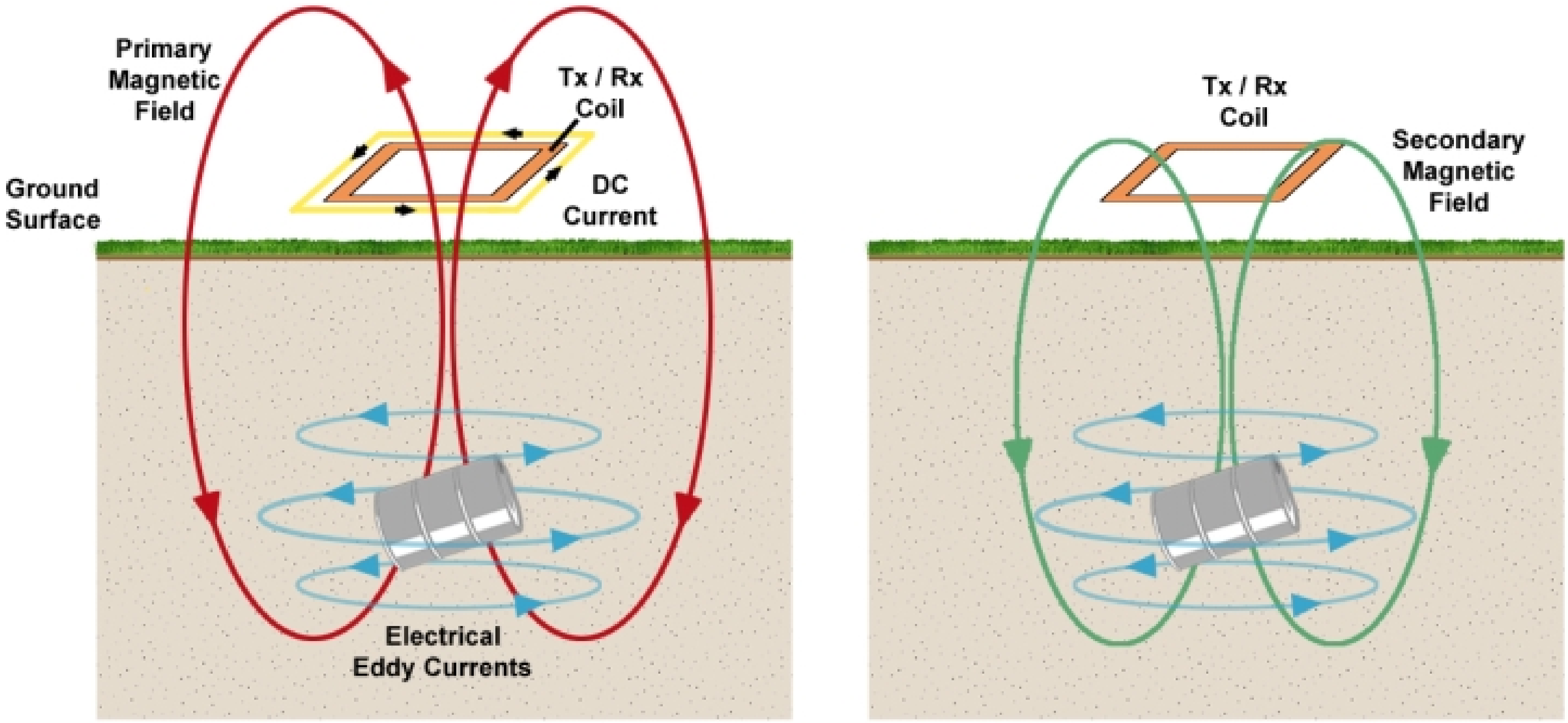
Title
Field Photographs: Data Acquisition Equipment

Reference

Figure No.
2



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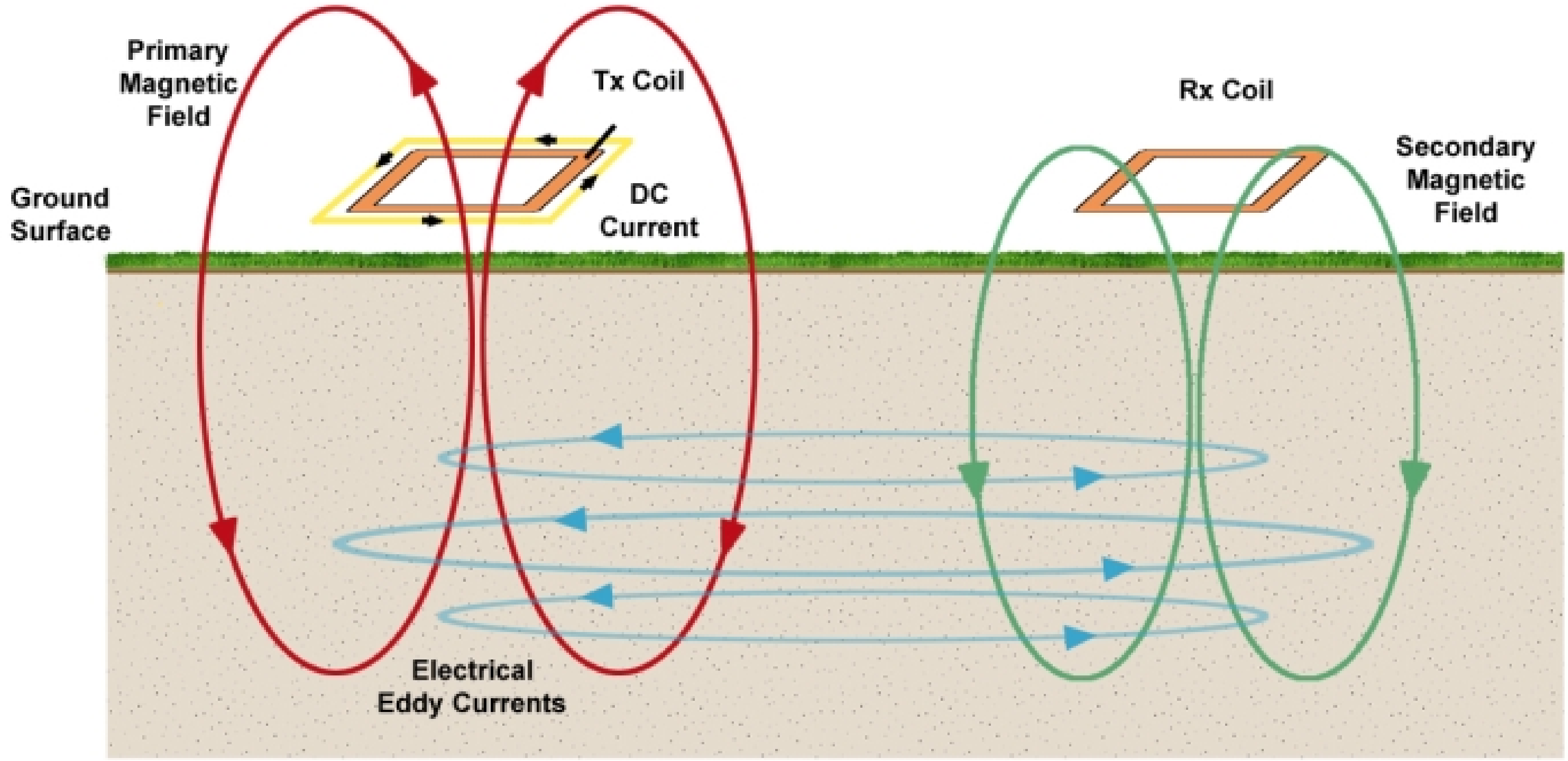
Title	Reference	Figure No.
EM61 Theory of Operation Schematic		3



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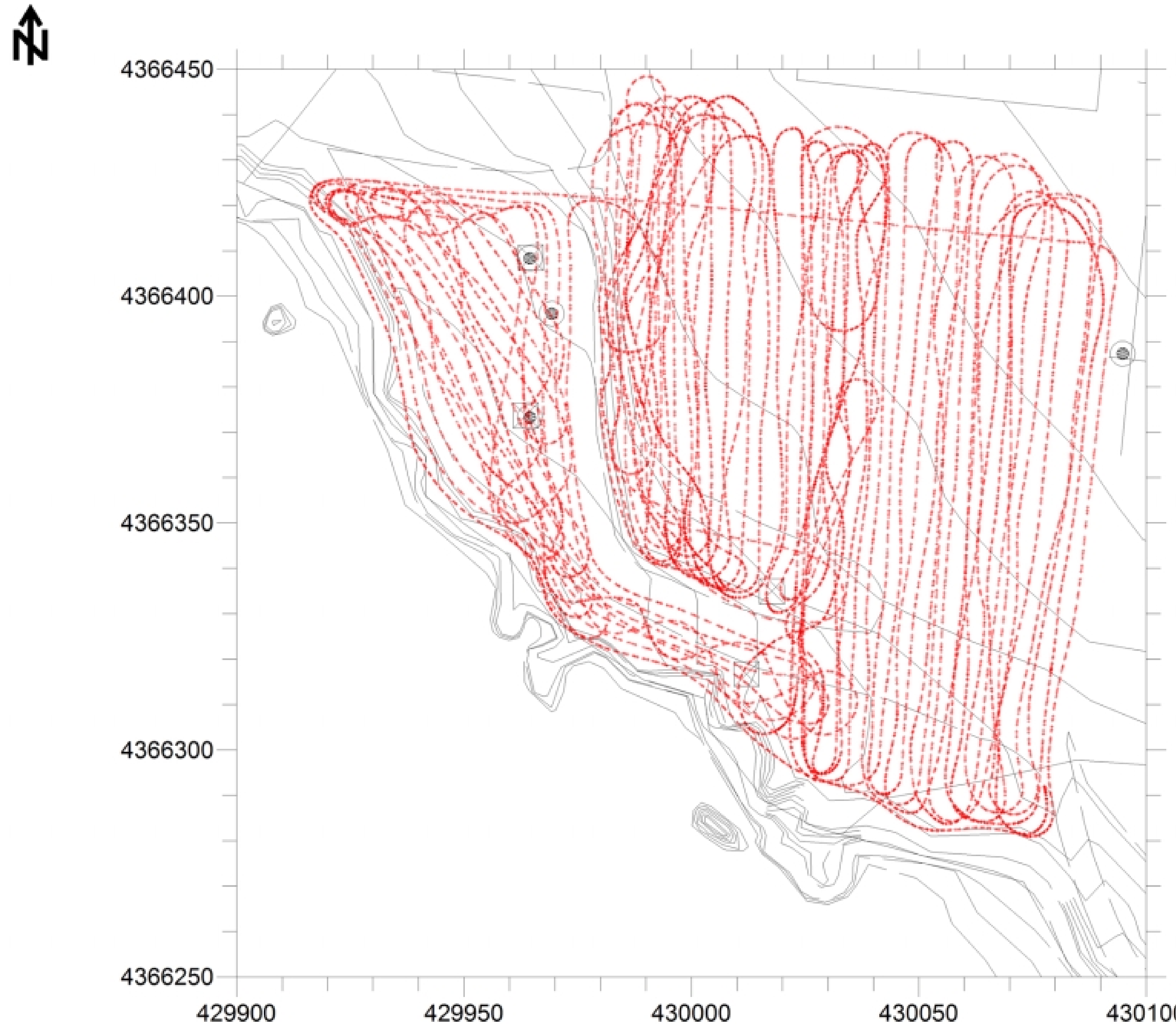
Title

EM31 Theory of Operation Schematic

Reference

Figure No.
4



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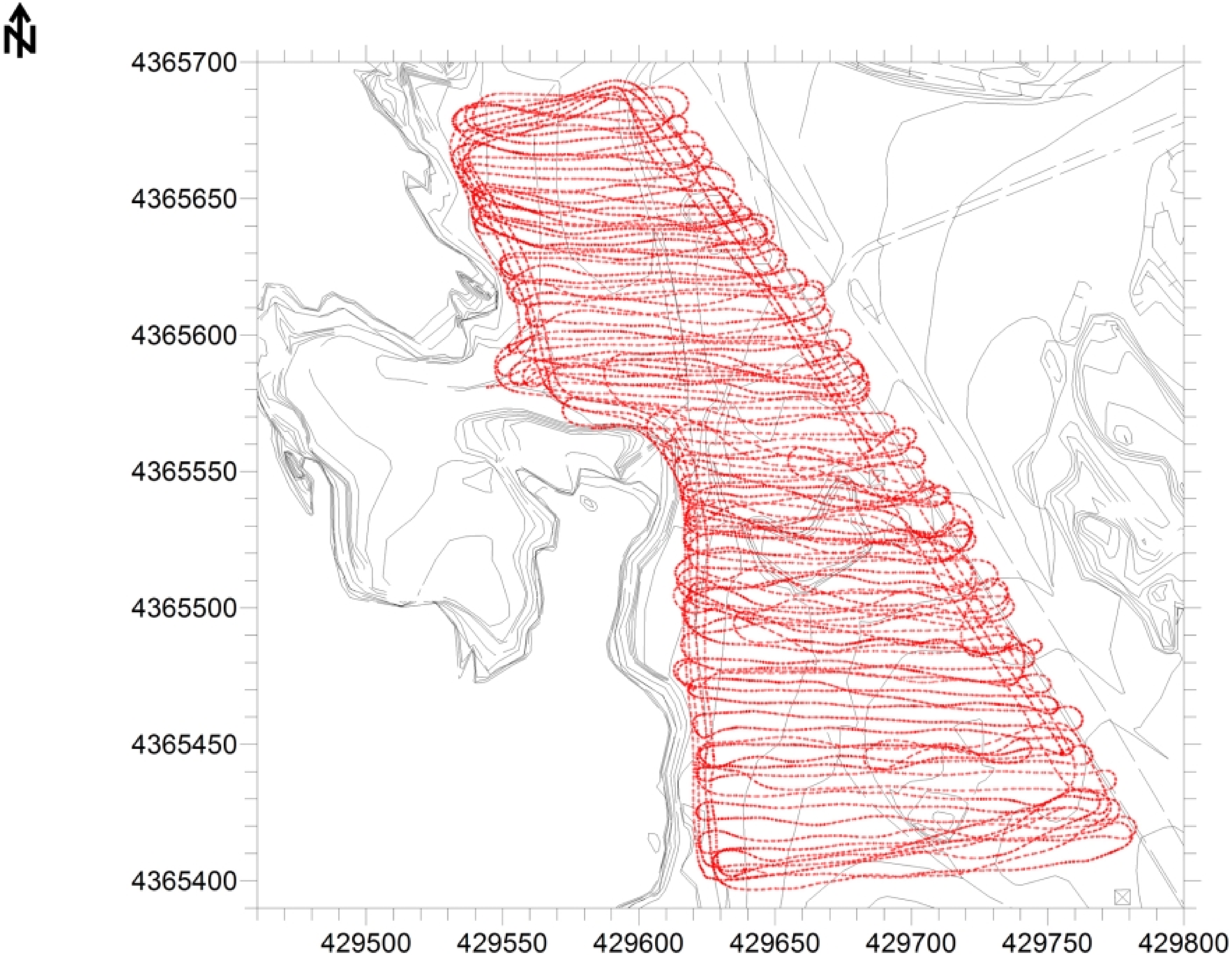
Title

EM61 Data Coverage Map: Parcel 3

Reference

Figure No.
5



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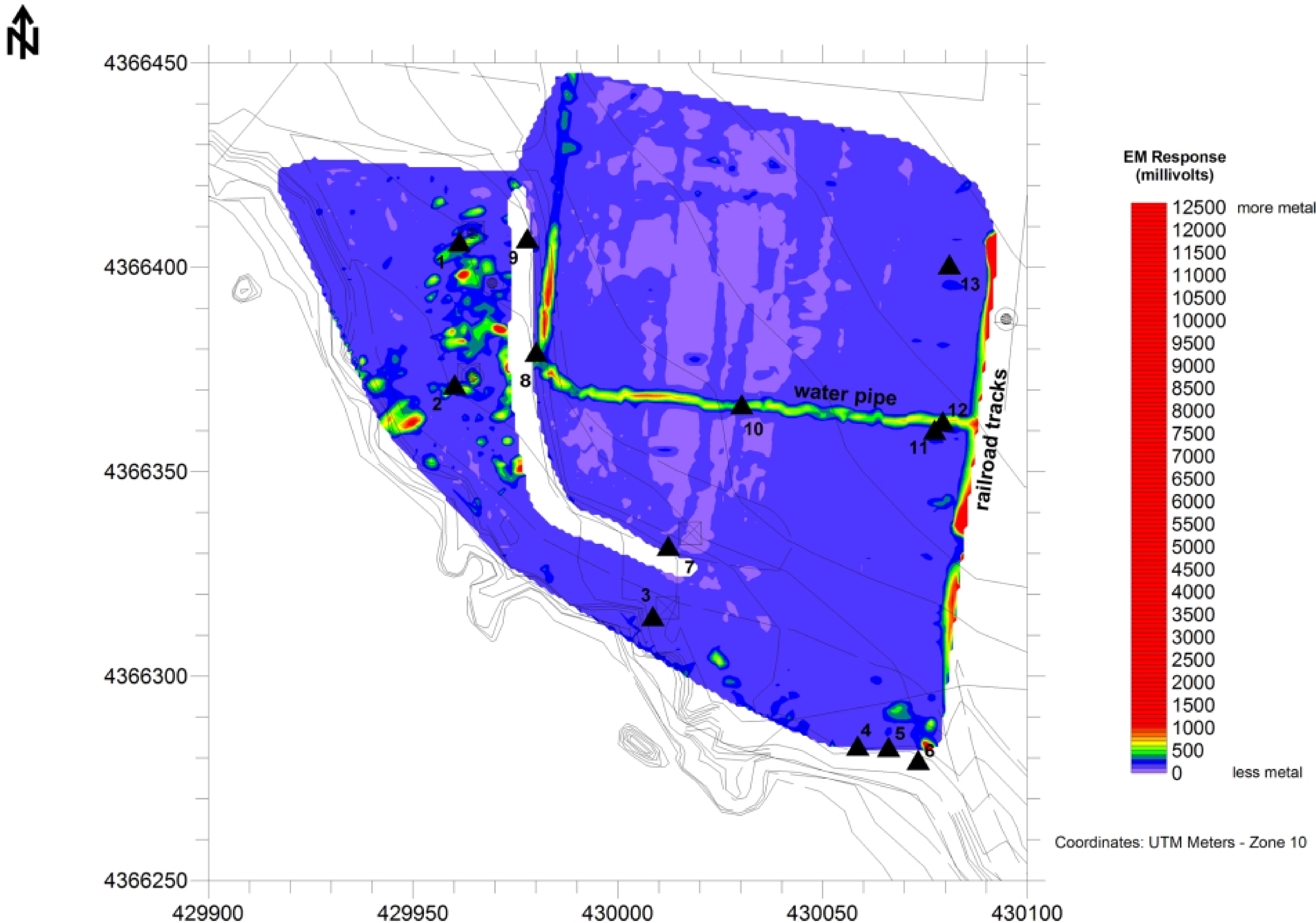
Title

EM61 Data Coverage Map: Parcel 10

Reference

Figure No.
6



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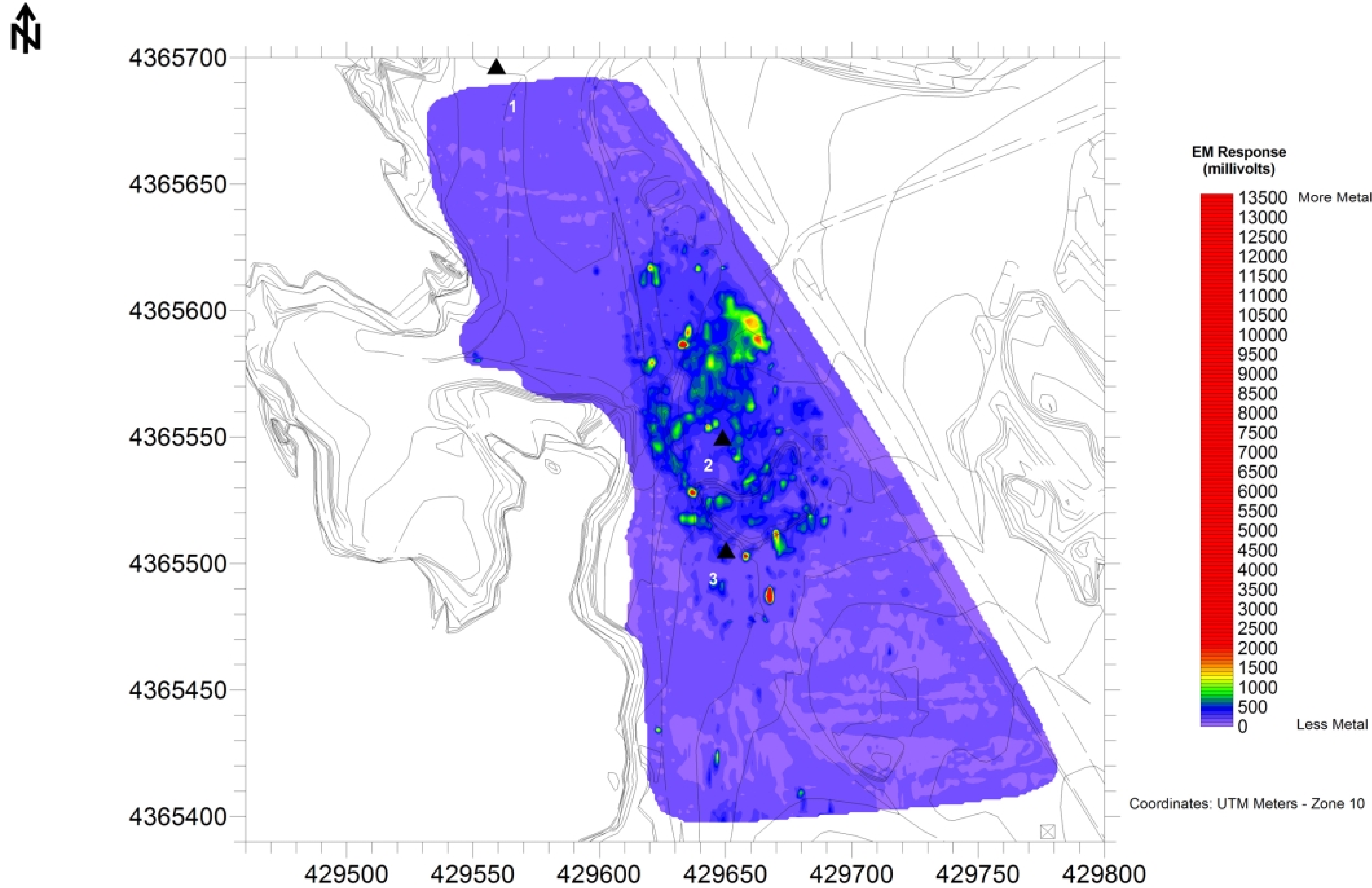
Title

EM61 Anomaly Map: Parcel 3

Reference

Figure No.
7



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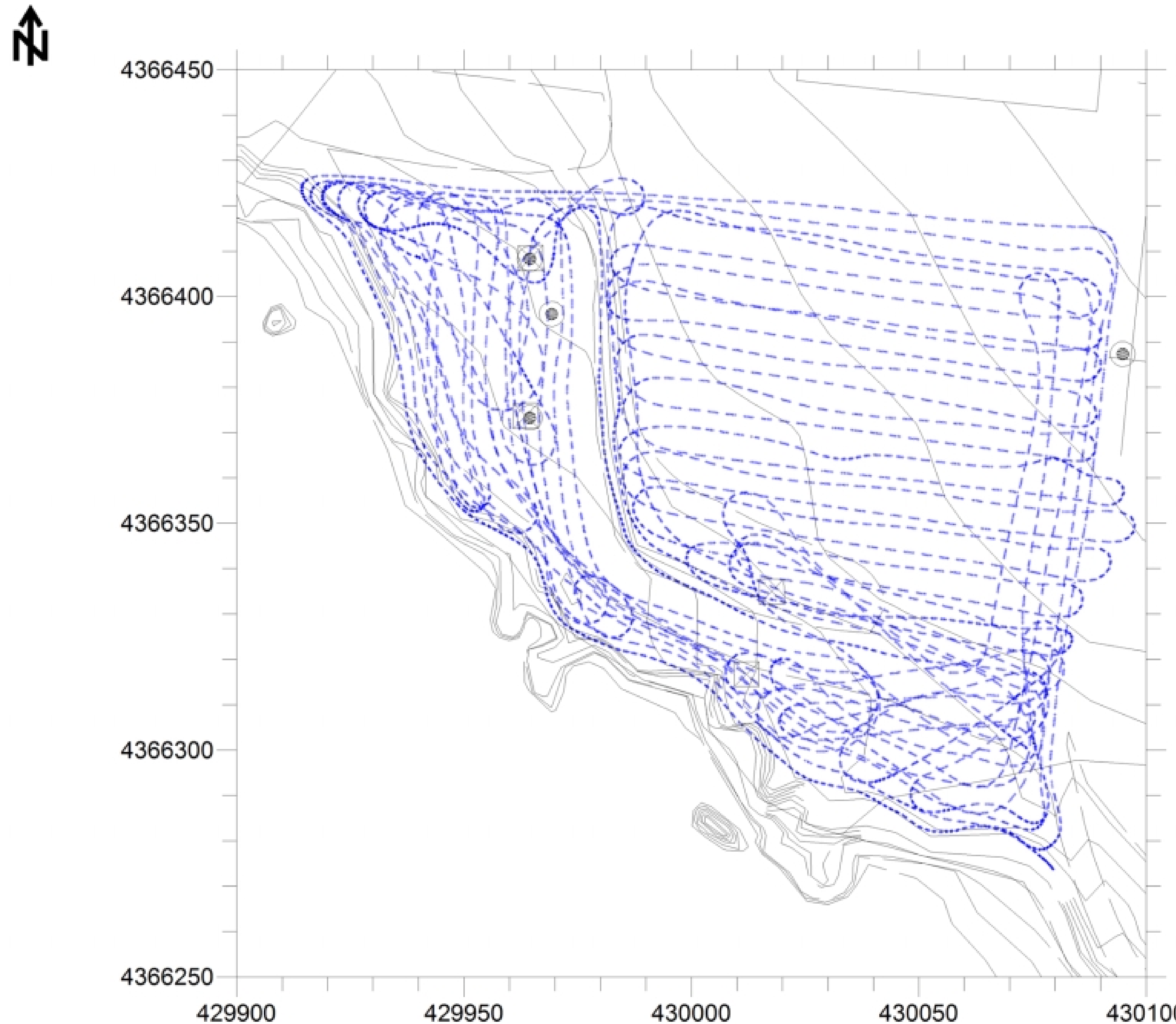

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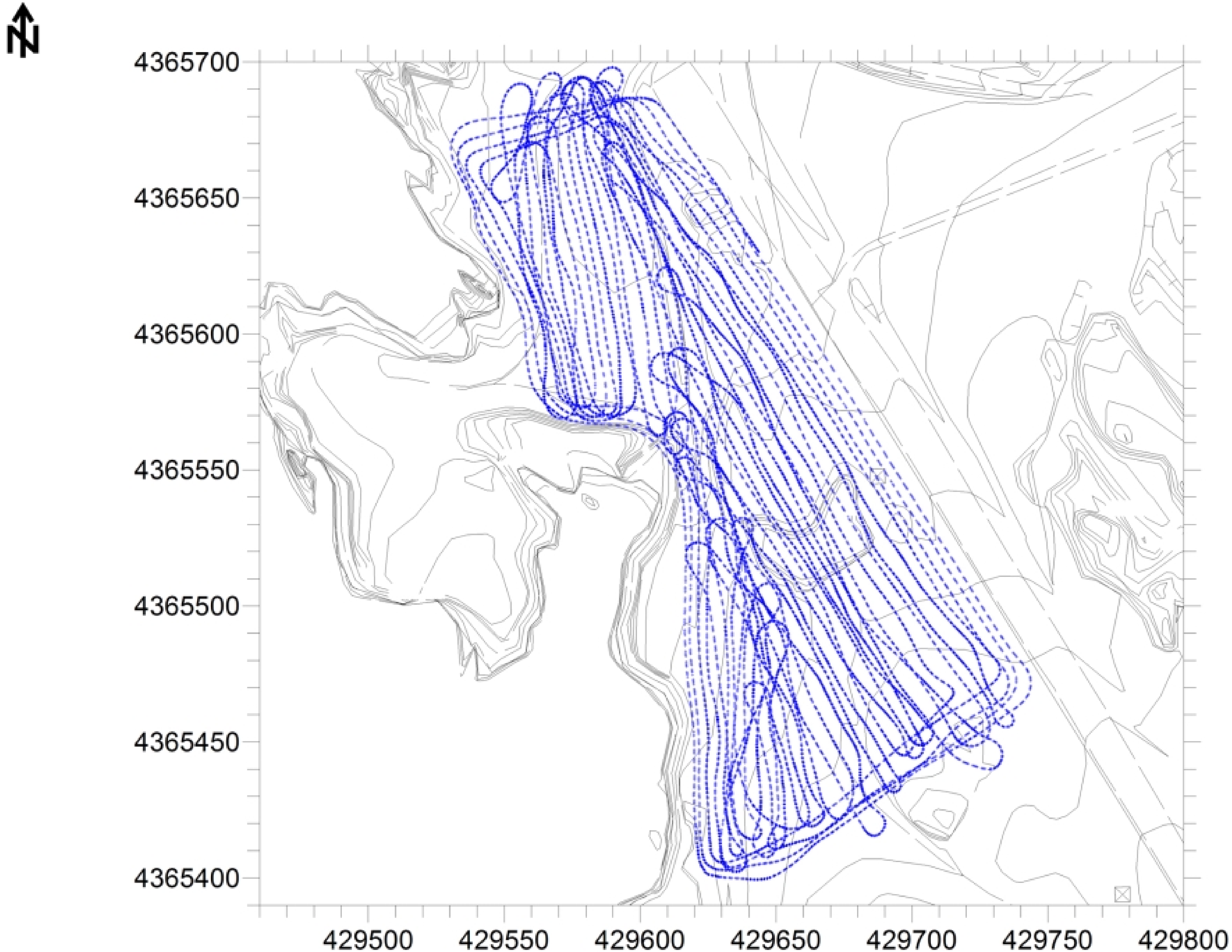
Title

EM31 Data Coverage Map: Parcel 3

Reference

Figure No.
9



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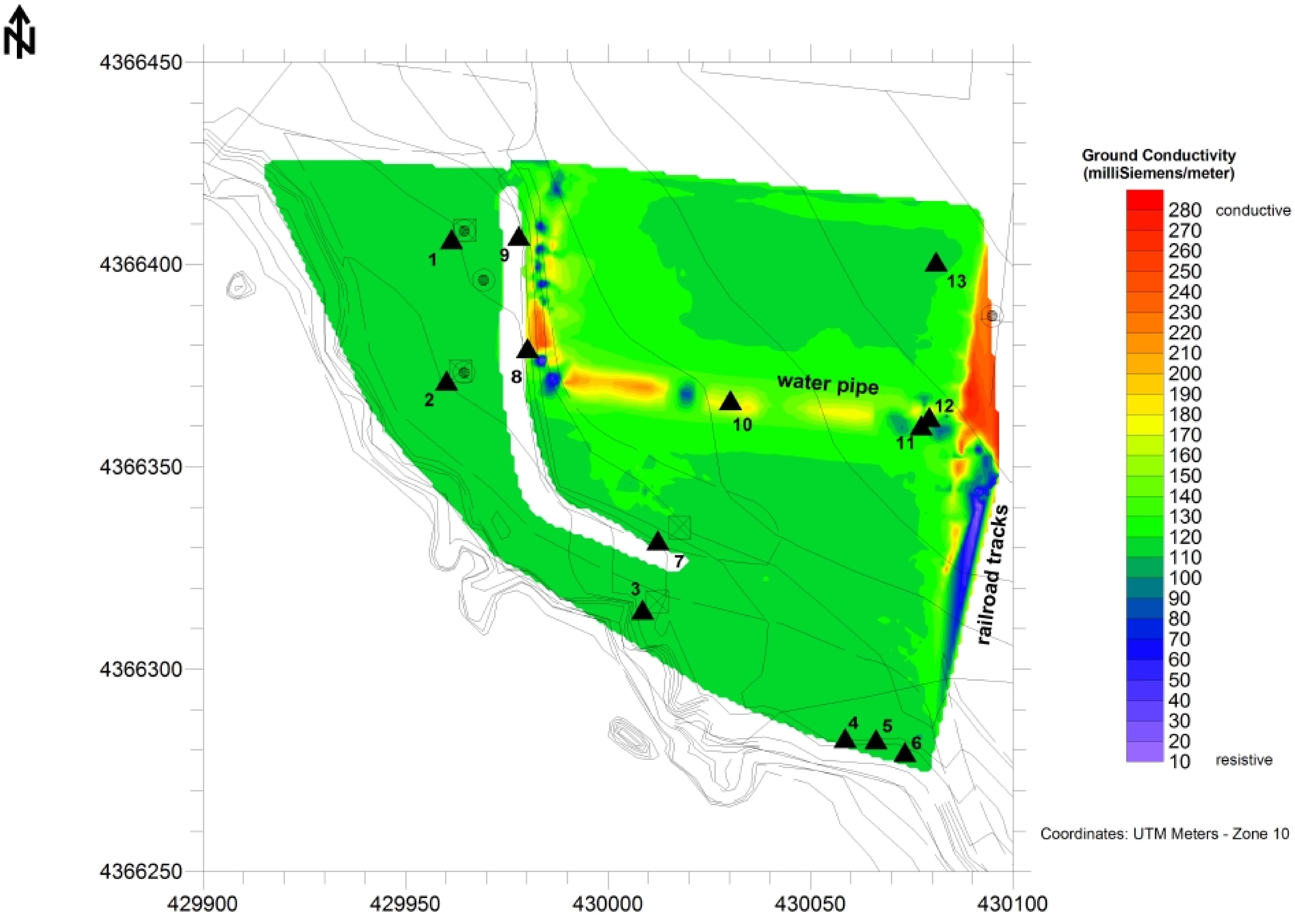
Title

EM31 Data Coverage Map: Parcel 10

Reference

Figure No.
10



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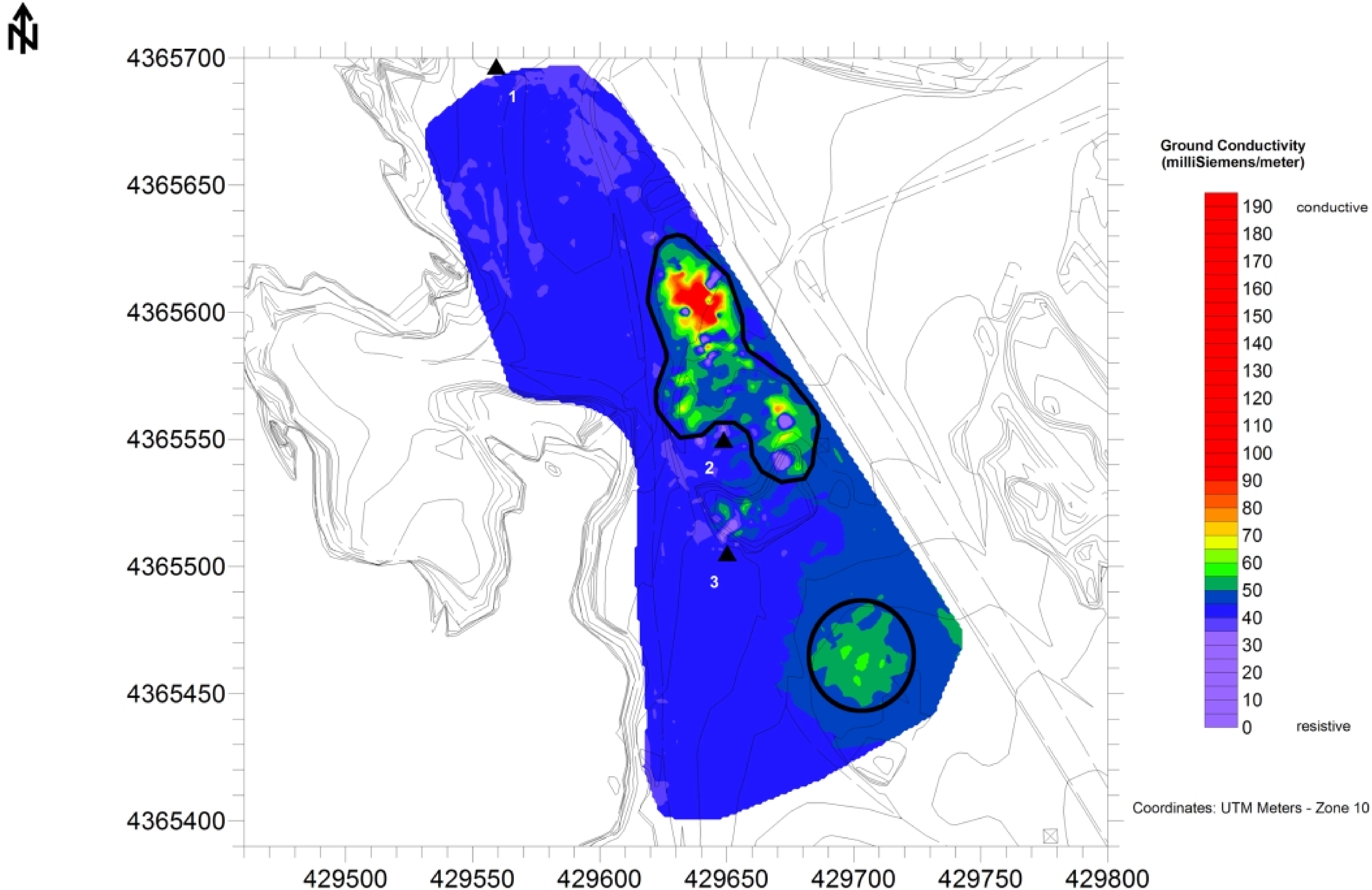
Title

EM31 Anomaly Map: Parcel 3

Reference

Figure No.
11



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Title

EM31 Anomaly Map: Parcel 10

Reference

Figure No.
12